



## Global Trends of Lake Surface Temperatures Observed From Space

P. Schneider (1) and S. J. Hook (2)

(1) NILU - Norwegian Institute for Air Research, Norway (ps@nilu.no), (2) Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, United States

The water temperature of lakes and other inland water bodies is a good indicator of climate variability. Unfortunately, the existing record of sufficiently long, homogeneous, and reliable in situ measurements is very sparse on a global scale and is nearly non-existent in many less developed parts of the world. Satellite-based thermal infrared (TIR) remote sensing is currently the only feasible method to provide a consistent and global overview of lake temperatures and provides a nearly 30-year record for determining trends.

Here we present results from a trend analysis performed at large lakes worldwide using satellite-based TIR data from the series of Advanced Very High Resolution Radiometers (AVHRR) and the series of Along-Track Scanning Radiometers (ATSR) between 1985 and 2009. Time series of surface water temperature were extracted over 169 study sites worldwide and a linear regression model was fitted to the seasonal summertime means. A validation of the computed trends at the North American Great Lakes shows that the satellite-derived trends closely match corresponding trends obtained from in situ data measured at buoys in the lake. Subsequently, trends were computed for all study sites and the results indicate that overall the water bodies have warmed at an average rate of  $0.045 \pm 0.011$  °C/yr ( $p < 0.001$ ). No significant cooling trends were found. A map of the spatial distribution of the trends shows far greater warming in the mid- and high latitudes of the northern hemisphere than at low latitudes and the southern hemisphere. The strongest increasing trends were found over Northern Europe where rates as high as  $0.10 \pm 0.01$  °C/yr were measured for the period 1985–2009. From there the rates decrease slightly towards southeastern Europe and towards Asia. Lakes in North America have been warming at average rates of around 0.05 °C/yr. At lower latitudes, most inland water bodies showed much slower trends or no significant change. A comparison with data from the GISTEMP surface air temperature analysis shows qualitatively that the spatial patterns found for the lake temperature trends agree reasonably well with those found for surface air temperature over the same period.

Overall, our study demonstrates that the existing record of TIR satellite data offers the opportunity to estimate temperature trends of inland water bodies at a large number of sites worldwide and that many large lakes have been subject to significant warming since 1985.